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A SPECTROSCOPIC RECONNAISSANCE OF UV-BRIGHT STARS[1]

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ABSTRACT

We have carried out spectroscopic observations and made preliminary classifications of 62 UV-bright stars identified by Lanning on plates taken by A. Sandage. The goal was to search for "interesting" objects, such as emission-line stars, hot sub-dwarfs, and high-gravity stars. Our targets were grouped into two samples, a bright ($m_{\rm B} < 13$) sample of 35 stars observed with the Kitt Peak 2.1m telescope and a faint ($13 < m_{\rm B} < 16$) sample of 27 stars observed with the *Hobby-Eberly Telescope*. We find 39% fairly normal O–mid B stars, 15% late B–late A stars and 32% F–G stars, with 13% of the stars being high gravity objects, composite, or otherwise peculiar. Included are four emission-line stars, three composite systems. Thus one out of every ten Lanning stars is "interesting" and may deserve individual study. Stars in the bright sample are often found to be late F or early G stars, although this sample does include interesting stars as well. No such large contamination occurs among the fainter stars, however, owing to "deselection" of these stars by interstellar reddening in the low-latitude fields of the survey.

Subject headings: stars–early-type, stars–emission-line, stars–white dwarfs, stars–subdwarfs

1. INTRODUCTION

Lanning has published six lists of UV-bright stars in the Galactic Plane, based on eye inspection of two-color photographic plates obtained by A. Sandage using the Palomar Schmidt telescope (Lanning 1973; Lanning & Meakes 1994, 1995, 1998, 2000, 2001). Magnitudes range from about 10 to about 20, with $U-B$ colors typically bluer than -0.2. As demonstrated by Margon & Downes (1981) the Lanning lists are a potentially rich source of rare or important objects, if the stars can be observed spectroscopically. Those authors reported spectroscopy of nineteen objects drawn from list I, finding two emission line objects in the group. Of these, one turned out to be a cataclysmic variable (Lanning 10 = V363 Aur) and the other is an emission-line shell star. Other Lanning stars have turned out to be previously known objects, such as HZ Her (Her X-1), WZ Sge (a recurrent nova), white dwarfs, central stars of faint planetary nebulae (e.g., HFG 1), and various stars named in the Luminous Stars of the Northern (or Southern) Milky Way Survey (LS/LSS).

Since lists II–VI of the Lanning catalog have been published relatively recently, such spectroscopy is not generally available in the literature for most of the 459 objects. As noted above, some Lanning stars have proposed cross-identifications with previously known objects, based on positional and magnitude coincidence. However, besides the objects examined by Margon & Downes (1981), or followed up by others after that work called attention to them, only Lanning 90 = V1776 Cyg (Shafter, Lanning & Ulrich 1983; Garnavich et al. 1990) and Lanning 159 (Liu & Hu 2000) have been newly described spectroscopically. Thus we have undertaken a spectroscopic reconnaissance of a subset of Lanning stars, the results of which are the subject of this paper.

In §2 we describe the target selection, observations and data reduction. In §3 we present our classification of the spectra and a census of interesting objects, which we discuss in more detail in §4. We close with a brief summary of our findings in §5.

2. TARGETS, OBSERVATIONS, AND DATA REDUCTION

We selected two samples of stars from lists I, II and (mostly) V by Lanning (1973) and Lanning & Meakes (1994, 2000), which we refer to hereafter as the "bright" and "faint" samples. This selection was dictated in part by the timing of our observing runs. The stars lie along the northern Milky Way between Right Ascensions 19h and 22h and in the declination range $+18°$ to $+62°$. Updated coordinates of all Lanning stars along with any proposed cross-identifications can be found at `http://www.stsci.edu/~lanning/index.html`. In general, we have selected stars for spectroscopic follow-up which do not have existing cross-identifications. More than half of all the targets and all of the members of the bright sample are from the recently published and therefore poorly studied list V (Lanning & Meakes 2000). The sample of stars that we observed is representative of the range of $U-B$ colors of stars included in these lists, and it should be representative of the types of stars to be found in the magnitude range examined.

[1] Based, in part, on observations with the *Hobby-Eberly Telescope*.

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The bright sample includes 35 stars brighter than $m_B \approx 13$, while the faint sample includes 27 stars with $m_B = 13 - 16$. The members of the two samples are listed in Tables 1 and 2. Two of the stars of the faint sample were observed more than once, with different observations appearing as separate entries in Table 2.

The bright sample stars were observed with the Kitt Peak National Observatory's (KPNO) 2.1m telescope and GoldCam spectrograph on 2000 September 24–25 with exposures of 300 s. The observation epochs are listed in Table 1. We used a $1\farcs8$ slit and a 500 mm^{-1} grating to achieve a spectral resolution of 4.9 Å over the spectral range 3875–7530 Å. The observations were made either during small gaps in the primary observing schedule or during marginal weather.

The observations of the faint sample were carried out in queue-scheduled mode with the *Hobby-Eberly Telescope* (*HET*) and Marcario Low-Resolution Spectrograph (LRS) in 2000 May and July with exposure times ranging between 120 and 1500 s. The specific observation epochs as well as the exposure times are listed in Table 2. We employed a $1''$ slit and a 600 mm^{-1} grism, which yielded a spectral resolution of 4.5 Å and covered the range 4260–7245 Å.

The spectral resolution and spectral coverage used in the observations obtained with the KPNO 2.1m telescope were determined by the objectives of the unrelated, primary observing program. In the case of the *HET* observations, we chose the highest resolution mode available with the LRS; note that the spectral coverage is determined by the choice of grism. The resulting resolution and wavelength coverage are similar for the two instruments but differ from those normally used in classifying stars on the MK system. They are, however, well-suited for our purpose of carrying out a reconnaissance of Lanning stars, where the goals are to assess the distribution of spectral types and to identify unusual objects for possible later study. The coverage of redder wavelengths (Hα, molecular bands) is especially useful for the latter goal.

The spectra were reduced in a standard manner. In summary, following bias subtraction and flat field division, we traced and extracted spectra from a wide window along the slit, which included most of the stellar flux, subtracting the contribution from the night sky. An initial wavelength scale was derived from spectra of arc lamps taken either at the beginning of the night or interspersed among the target observations. The root-mean square residuals of a polynomial fit to the arc line wavelengths were less than 0.1 pixels. The zero point of the wavelength scale was refined with the help of strong night-sky emission lines that were recorded in the same exposure as the star, yielding a final absolute scale good to 0.3–0.5 Å. The flux scale was established with the help of observations of spectrophotometric standard stars. Uncertainties in the relative flux scale are less than 10% throughout most of the spectral range and increase to 15–17% at wavelengths longer than 6500 Å. The absolute flux scale can be uncertain by as much as a factor of 2, especially in the case of the *HET* observations, since the spectra were taken through a narrow slit to assure best resolution under variable seeing and fluctuating image quality. Discrete atmospheric absorption bands were corrected using templates derived from the spectra of the spectrophotometric standards stars, which are featureless in the regions of interest.

3. CLASSIFICATION AND CENSUS OF INTERESTING OR UNUSUAL OBJECTS

In order to classify the program stars, we used the digital *Library of Stellar Spectra* (Jacoby, Hunter, & Christian 1984) as a source of "standard" comparison spectra. This was possible since the resulting resolution of our spectroscopy is very similar to theirs, and the overlap in wavelength coverage is adequate.

For classification purposes it was desirable to remove the major effects of interstellar reddening from the observed spectra, especially since the Jacoby et al. spectra were published with this correction applied. At the same time, it was desirable to retain some of the undulations in the spectrum that help to indicate spectral type. We thus *approximately* normalized both the program and standard spectra in the same way, using a broken straight line fit: we divided the blue portion of each spectrum by a straight line connecting the average flux density in a small "blue" wavelength interval to the average flux density in a small "yellow" interval, and we divided the red portion of each spectrum by a straight line fit connecting the same yellow interval with the average flux density in a small "red" wavelength interval. Thus the spectra are pivoted about the center of the yellow interval, which is at 5500 Å. (The blue and red intervals are centered at 4040 Å and 7030 Å, respectively, for the spectra acquired at KPNO; and at 4410 Å and 7030 Å, respectively, for the spectra acquired at the *HET*. For comparison with a given program star's spectrum, the Jacoby et al. standard spectra were normalized with the appropriate choice of intervals.) This approximate normalization sufficed to remove the major effects of interstellar reddening (which resembles a line broken at 5500 Å) and the bulk of the curvature of the intrinsic spectrum of each star, leaving shorter-scale undulations along with the absorption line spectrum of each star. Our normalization scheme is simple, rapid, and objective in execution, and entirely adequate for the purposes of our present study.

A rough classification was then carried out by visual inspection, comparing a subset of the spectra from Jacoby et al. with each program star. The subset of Jacoby et al. stars included stars of spectral type O7, O9, B0, B3, B8, A2, A3, A7, F0, F6, G0, K0, K4, M0, and M5, all of luminosity class V, along with two metal-weak stars of types F4 and F7. Normalized line depths and line depth ratios were the principle diagnostics of spectral type. Additional information was drawn from the shape of the continuum after normalization. The main purpose of the classification was to divide the program stars into early and late spectral types and to note unusual spectra, including composite-spectrum and high-gravity stars. The entire observed wavelength range was used initially. For the bright sample, the classification was repeated using expanded plots of the 3800–5300Å region, and these classifications are preferred in Table 1; the two classifications were usually consistent, in one case a dubious classification being clarified using the expanded "blue" plots. Further refinement in the spectral types, perhaps especially with respect to luminosity class of the earlier stars, may be possible with the present data, but such work would be better pursued with data that have somewhat higher resolution and additional coverage at shorter wavelengths. Our estimated spectral types are given in Tables 1 and 2, along with brief notes where warranted. In some cases a range of possible spectral types is given. In other cases, the best matching type from the set of standards is given; in this case a tilde (∼) preceding the type indicates a somewhat broader range of allowed matches is possible but could not be explored with our sparse selection of standards. A colon (:) indicates a difficult classification.

Of the 35 stars in the bright sample, we classify seven stars as O to mid-B, nine stars as late-B to late-A, and nineteen stars as F or G. This group includes a large number of late F to early G stars. These are likely metal–poor or have large individual color errors, in order to have a sufficiently extreme $U-B$ color for inclusion in the catalog (see further discussion below). There are no obvious candidates for high–gravity stars. Some of the stars are strongly reddened, as shown by both the continuum shape before normalization and the presence of diffuse interstellar bands. For a sample of fourteen early-type stars an eye-estimate was made of the depth (in continuum units) of the unresolved λ6283 interstellar band. There is a positive but weak correlation between the band depths and $U-B$ color excesses, which were estimated using $U-B$ from Lanning & Meakes (1994, 2000) and intrinsic colors inferred from the assigned spectral types. Such a correlation is expected, since both interstellar absorption bands and reddening are due to "dust." Its weakness in the present sample is largely owing to observational scatter in the inferred and measured colors of the stars.

The fainter sample of 27 Lanning stars contains 16 stars classified by us as O or B, three stars called "hot, high gravity," five DA, DA + late-type, or other composite stars, one F–G star, one He-strong star, and a star surrounded by an emission nebula. In addition, we observed the M dwarf G209–30, which is a high proper motion star in the field of Lanning 93. This sample shows the reverse properties of the bright sample, namely it includes more high-gravity stars and only one late F–G star. We interpret this as a result of color "deselection" of marginal stars by interstellar reddening. F–G stars are expected to have $U-B$ colors redder than the nominal cutoff adopted by Lanning for generating the catalog from the Sandage plates. They can, however, enter the Lanning sample if they are metal weak (i.e., subdwarfs, with reduced line blocking in the ultraviolet) or if the individual photometric errors are large; in either case, their $U-B$ colors will still be close to the cutoff. Fainter stars on average will be more distant, hence more heavily reddened, so that F–G stars among them no longer appear in a color-selected catalog, even if they are subdwarfs or in the case of large photometric errors. Likewise, many (but not all) luminous OB stars may be very heavily reddened if they are apparently faint in these Milky Way fields. Thus fainter Lanning stars in the sample tend to be of lower intrinsic luminosity, since that is what remains of the unreddened nearby sample; or to have very negative intrinsic $U-B$ color, to withstand significant reddening.

Several unusual spectra, including composite hot+cool systems, emission line stars, and He-strong stars were found. In particular, Lanning 121, Lanning 386 and Lanning 441 are composite, with Mg I b, Na I D, TiO and other absorption features indicative of a late-type star apparent in the spectra, along with H or He I lines from a hotter star. Lanning 388 is "He-strong," that is, moderately strong He I and He II lines are present along with strong H Balmer lines; He I λ4922, for example, is nearly as deep as Hβ, unlike in the stars from the Jacoby et al. atlas to which it was compared (HD 35619 O7 V, HD 12323 O9 V, HD 158659 B0 V).

Several of the 62 Lanning stars sampled are thus "interesting", not counting DA white dwarfs and other possible high-gravity stars. In the following section we discuss the properties of some of these objects further.

4. NOTES ON INDIVIDUAL OBJECTS

For the emission-line stars discussed below, we attempted to use the strength of the λ4430 diffuse interstellar band (DIB) to estimate the reddening and hence the extinction and distance. We prefer this method instead of comparing observed spectral energy distributions (SEDs) and intrinsic SEDs inferred from the spectral types, because uncertainties in the inferred spectral type are large enough that the intrinsic SEDs of the stars cannot be accurately determined. Moreover, the spectra of these stars include emission lines and therefore possibly a non-stellar continuum, which could distort the observed SEDs. We used the calibrations of the λ4430 DIB as a reddening indicator reported by Wampler (1963, 1966), Herbig (1975), and Tüg & Schmidt-Kaler (1981) and we have assumed a relationship between visual extinction and distance of $A_{\rm V}/d = 0.8$ mag kpc^{-1} (Allen 1973). Using the resulting distances and extinction-corrected fluxes, we are able to report approximate emission-line luminosities. Uncertainties in reddening, assessed from the dispersion of results obtained from different methods, are of order 0.2 mag. Uncertainties in the absolute flux calibration due to slit losses lead to error bars of a factor of 2 in quoted luminosity. There is also an uncertainty in converting visual extinction to distance, which is more difficult to assess in patchy Milky Way fields, that we have not taken into account.

Lanning 19 and Lanning 21. — Very broad and rather shallow absorption lines of H are present in these stars. If present, He I is very weak.

Lanning 23. — Observed by Margon & Downes (1981) who remarked, "Balmer abs; late B?". Fleming et al. (1996) classified this star as DA1; it was detected in the ROSAT All-Sky Survey.

Lanning 121. — Very broad absorption lines of H, but not He, are present, along with atomic and molecular band features indicating a late–K or M-type companion star. The spectrum is shown in Figure 1.

Lanning 384. — This star, which is located in Cygnus, is surrounded by an extended, emission-line nebula, whose spectrum includes many strong permitted and forbidden lines from a wide range of ionization states (from S II to He II). The spectrum of the star itself is rather blue with no obvious absorption lines; some filling in by emission may have occurred. The nebula is visible in the red, second-generation Palomar Observatory Sky Survey plate of this region. It is elliptical in shape with a major axis of length 4′, oriented approximately E–W. The inner part of the nebula is particularly bright and appears to define an inner ellipse whose major axis is approximately at right angles to that of the outer nebula. By chance, the spectrograph slit was set at a position angle of 270°, which is along the major axis of the outer nebula. The sky-subtracted 2-dimensional spectrum shows the low-ionization emission lines ([S II] $\lambda\lambda$6717,6731, [N II] $\lambda\lambda$6548,6583, Balmer lines) extending along the entire length of the slit of $4'$. There are knots of enhanced emission in the strongest low-ionization lines at a distance of about $45''$ from the central star, which also appears to be the extent of the He II-emitting region of the nebula. The spectrum of the innermost parts of the nebula, extracted from a window of width $10''$, is shown in Figure 2, and the relative emission-line strengths measured from it are reported in Table 3, with no extinction corrections applied. Since the slit was oriented at the parallactic angle during this observation, the relative line strengths should not be distorted by differential atmospheric refraction at the slit. From the relative strengths of the emission lines we can infer some of the basic properties of the inner nebula. If we require that the intrinsic Hα/Hβ ratio follows case B recombination, we infer a reddening of $E(B-V)=0.2$. From the ratio of [O III] $\lambda\lambda 4959, 5007$ to [O III] λ4363, we estimate a temperature of 15,000 K, while from the ratio of the lines in the [S II] $\lambda\lambda 6717, 6731$ doublet we estimate an electron density of 120 cm^{-3} (**?**, see)]osterbrock89. The mean heliocentric velocity of this nebular gas is -40 km s^{-1}, measured from eleven permitted and forbidden transitions.

Lanning 386. — The spectrum of this star sports a blue continuum with He I absorption lines as well as late-K or M features plus broad Balmer emission lines. From the strength of the λ4430 DIB we estimate $A_{\rm V}=1.5\pm0.2$, hence a distance of 1.9 ± 0.2 kpc and an Hα luminosity of 1.3×10^{32} erg s^{-1}. The Hα/Hβ ratio is 1.4 and the lines are rather broad: the Hβ line has a FWHM of 820 km s^{-1} while the Hα line has a FWHM of 1140 km s^{-1} (corrected for instrumental broadening). The flat Balmer decrement together with the emission-line luminosities and widths suggests that this is a cataclysmic variable or related interacting binary. The spectrum is shown in Figure 2.

Lanning 388. — An OB star with strong He I and He II lines (see previous section).

Lanning 441. — Absorption lines of H, He I and He II are present, along with band heads indicating an M-type companion star. The spectrum is shown in Figure 1.

Lanning 446. — This Be star has Hα in emission, with the Hβ absorption line partly filled by emission. The continuum appears reddened by interstellar and/or circumstellar absorption and the strength of the λ4430 DIB implies $A_{\rm V}=0.9\pm0.2$ leading to a distance of 1.1 ± 0.3 kpc and an Hα luminosity of 2×10^{33} erg s^{-1}. The Hα line is unresolved (down to a limiting FWHM of 230 km s^{-1}), which is consistent with an origin in circumstellar matter. The spectrum is shown in Figure 2.

Lanning 447. — Has shallow and possibly broad absorption lines, indicating it may be a sdO star.

Lanning 455. — This star shows both Fe II and Balmer emission lines. It appears as No. 469 in a list of Hα emission stars compiled by Merrill & Burwell (1950), and is also known as LS III +55°12. The continuum appears to be reddened and the λ4430 DIB implies $A_{\rm V}=2.3\pm0.2$ leading to a distance of 2.8 ± 0.2 kpc and an Hα luminosity of 1×10^{34} erg s^{-1}. The Hα/Hβ ratio is 6 (after reddening correction) and the FWHM of the Hα line is 430 km s^{-1} (corrected for instrumental broadening). The equivalent widths of the Hα and Hβ emission lines are 4.7 Å and 74.1 Å, respectively. The spectrum resembles those of T Tauri stars in the collection of Cohen & Kuhi (1979), suggesting that this object may be a T Tauri star as well. If so, the reddening and distance quoted combined with an apparent visual magnitude of ≈ 12 would imply a very luminous, hence young object.

5. CONCLUSIONS

We have obtained spectra and made preliminary classifications of 62 UV–bright stars. Of these 62 objects, four are emission-line stars, three are composite systems (double-counting one emission-line star), and another shows strong He I absorption lines. From the perspective of spectral classification, we find 39% more or less normal O–mid B stars, 15% late B–late A stars and 32% F–G stars, with 13% of the stars being high gravity objects, composite, or otherwise peculiar. Thus we reaffirm and greatly extend the conclusion to be inferred from Margon & Downes (1981) that at least one out of every ten Lanning stars is "interesting" and worthy of individual study.

Lanning stars brighter than $m_B=13$ are often found to be late F or early G stars, at least in the fields described in paper V (Lanning & Meakes 2000). No such large contamination occurs among the fainter stars, however, owing to "deselection" of these stars by interstellar reddening in the low-latitude fields of the survey. Interesting stars nevertheless do appear in the bright sample.

This work was based in part on observations obtained with the *Hobby-Eberly Telescope*, which is a joint project of the University of Texas at Austin, Pennsylvania State University, Stanford University, Ludwig-Maximillians-Universität München, and Georg-August-Universität Göttingen. The Marcario Low-Resolution Spectrograph (LRS) is a joint project of the Hobby-Eberly Telescope partnership and the Instituto de Astronomía de la Universidad Nacional Autónoma de México.

The original photographic survey by Sandage was supported in part by the National Aeronautics and Space Administration under grant NGR 09-140-009. NASA support to Lanning has been from the Astrophysics Data Program through contract PO# S-92513-Z. We have made use of the SIMBAD database operated at CDS, Strasbourg, France, and NASA's Astrophysics Data System Bibliographic Services.

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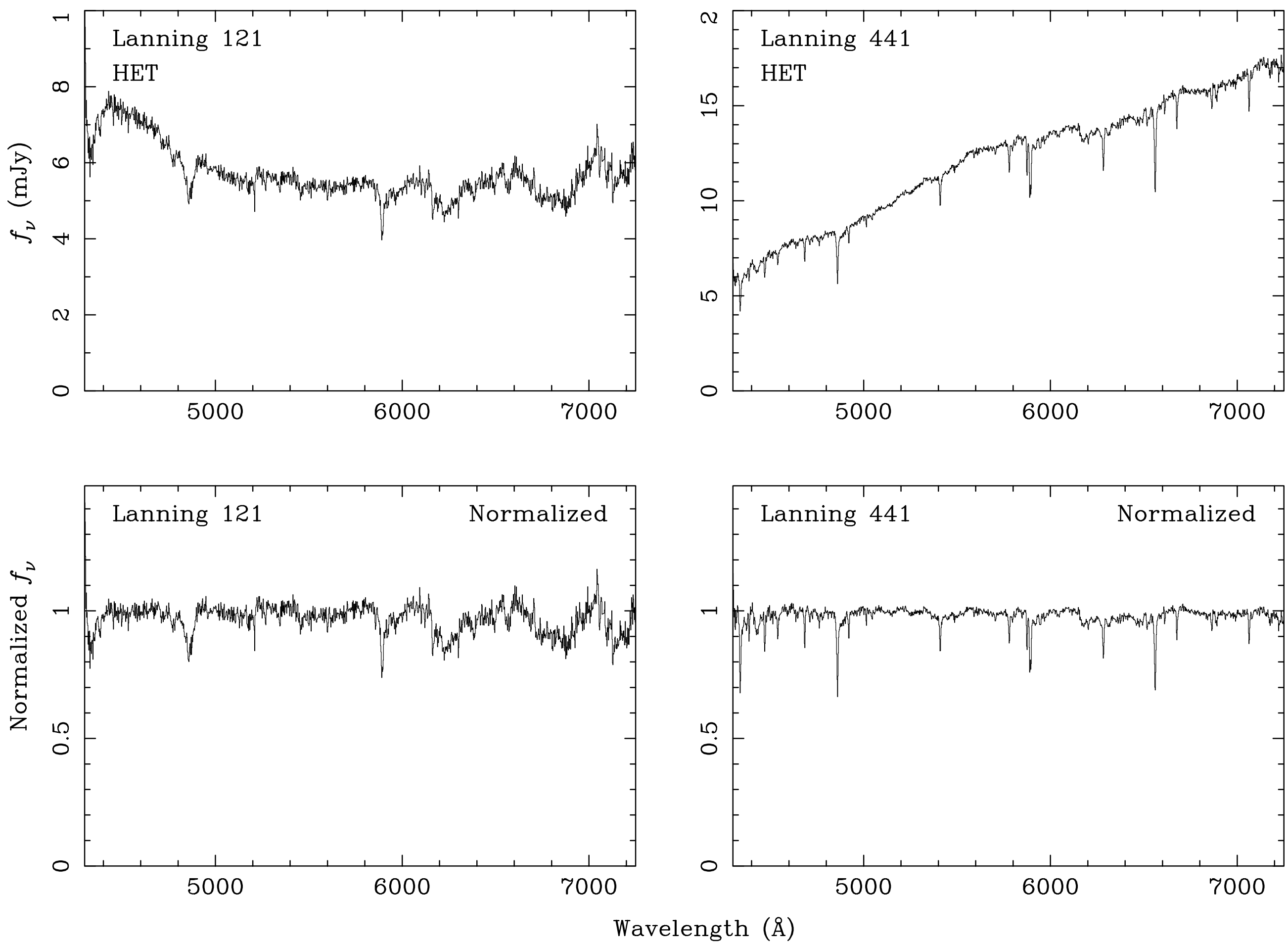

Fig. 1.— Spectra of Lanning 121 and Lanning 441 (both from the *HET*), showing their composite nature. The top panels show the original spectra, while the bottom panels show the normalized spectra. Their classification is given in Table 2 and their properties are discussed in §4 of the text.

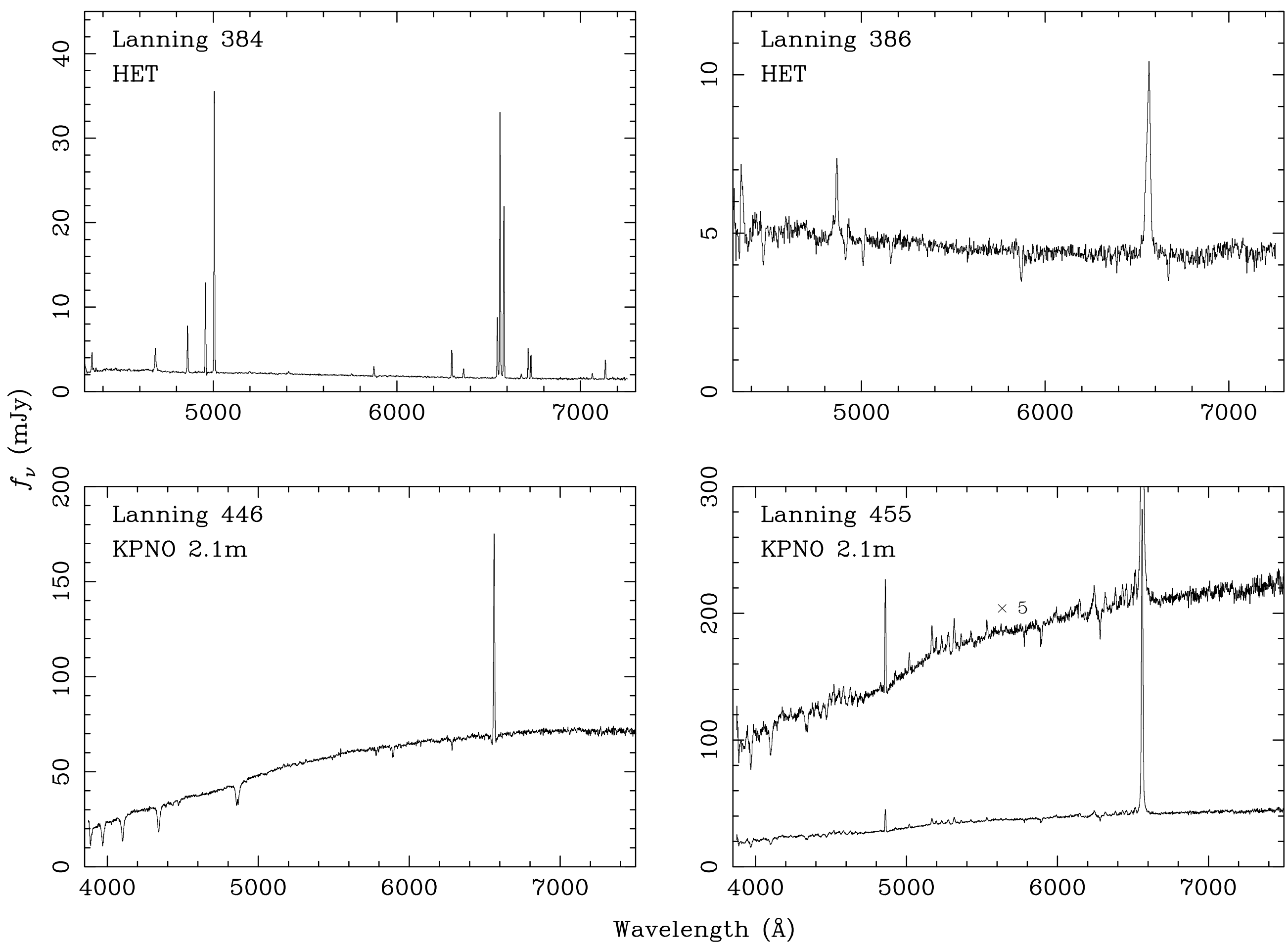

FIG. 2.— Spectra of the four emission line stars found. The first two objects were observed with the *HET*, while the last two were observed with the KPNO 2.1m. Their properties are discussed in detail in §4 of the text and their classification is given in Tables 1 and 2. In the case of Lanning 455 we also show a magnified view of the spectrum (by a factor of 5) to better illustrate the forest of Fe II lines.

Table 1
Bright Sample: Targets, Observations, Classification

Lanning Number	Approx. m_{B}	Observation Date and Time (UT)	Exposure Time (s)	Spectral Class	Notes
365	10.2	2000 Sep 24 06:50:55	300	B8	
368	10.5	2000 Sep 25 07:12:45	300	mid B	
369	10.6	2000 Sep 24 06:57:30	300	early G	
370	10.7	2000 Sep 24 07:25:41	300	mid F − G0	
371	10.5	2000 Sep 24 07:07:14	300	$\sim$ F6	
373	10.8	2000 Sep 25 07:24:41	300	B8	
374	10.8	2000 Sep 25 07:30:43	300	$\sim$ F6	
375	10.5	2000 Sep 25 07:18:45	300	$\sim$ F6	
378	10.7	2000 Sep 25 07:45:26	300	early G	
379	10.8	2000 Sep 24 07:13:39	300	G	
380	10.6	2000 Sep 25 07:06:41	300	late F − G	
381	10.6	2000 Sep 24 07:19:46	300	mid F	
390	11.0	2000 Sep 25 07:51:35	300	mid F	
393	11.3	2000 Sep 25 07:39:19	300	$\sim$ F6	
397	11.2	2000 Sep 24 08:52:17	300	$\sim$ B3	
398	10.8	2000 Sep 25 08:46:39	300	$\sim$ F8	
401	11.6	2000 Sep 25 07:58:17	300	late F − G	
404	10.8	2000 Sep 24 07:41:25	300	mid–late B	
405	10.8	2000 Sep 24 08:58:44	300	$\sim$ B8	
406	12.4	2000 Sep 25 06:58:25	300	late F	
408	12.2	2000 Sep 25 08:06:32	300	O7	
412	10.9	2000 Sep 25 08:40:28	300	O9 − B0	
419	10.5	2000 Sep 24 08:45:56	300	$\sim$ F6	
421	10.8	2000 Sep 25 08:28:36	300	late F − G	
428	10.9	2000 Sep 25 08:34:36	300	$\sim$ F6	
436	10.8	2000 Sep 25 08:21:37	300	$\sim$ B8	
446	12.0	2000 Sep 24 08:30:27	300	mid–late B	Hα em., weak Hβ abs.
447	11.0	2000 Sep 24 08:37:01	300	late O − early B	shallow H lines
448	11.5	2000 Sep 24 07:54:34	300	A0–A2	
449	12.2	2000 Sep 24 07:47:49	300	A7	
450	11.0	2000 Sep 25 08:15:37	300	late F − G0	
452	11.5	2000 Sep 24 08:08:05	300	late B	
453	11.3	2000 Sep 24 08:00:38	300	$\sim$ B3	
454	11.4	2000 Sep 24 08:14:31	300	G	
455	12.0	2000 Sep 24 07:32:18	300	O − early B:	H and Fe II emission

Table 2
Faint Sample: Targets, Observations, Classification

Lanning Number	Approx. m_B	Observation Date and Time (UT)	Exposure Time (s)	Spectral Class	Notes
19	15.5	2000 Jul 23 09:11:46	320	—	hot, high-g?
21	16.0	2000 Jul 08 08:29:00	240	—	hot, high-g?
		2000 Jul 10 10:06:14	620		
		2000 Jul 23 09:30:56	620		
22	14.7	2000 Jul 24 09:37:10	130	O7–O9	
23	14.0	2000 Jul 23 08:18:40	120	—	v. hot, high-g
44	13.0	2000 Jul 24 08:55:17	120	F8–G	
45	13.5	2000 Jul 01 10:29:40	120	mid-B	
49	14.5	2000 Jul 01 06:08:04	240	O	
80	14.5	2000 Jul 24 08:40:45	130	∼B5	
105	16.0	2000 May 04 10:31:33	520	∼B3	
106	13.0	2000 May 04 10:18:11	120	∼B3	
110	15.0	2000 May 04 10:49:48	200	mid-B	
121	15.0	2000 Jul 08 07:02:51	600	DA+late K–M	composite
354	15.5	2000 Jul 04 06:07:47	420	O–early B	
367	15.5	2000 Jul 08 06:23:00	540	B0–B3	
382	16.0	2000 Jul 04 06:34:10	600	mid-B	
384	16.5	2000 Jul 31 10:24:18	1000	—	emission nebula
385	16.0	2000 May 05 10:38:30	720	mid-B	
386	15.8	2000 Jul 10 06:03:23	430	He I abs.+late K–M0	broad H em.; comp.
388	16.5	2000 Jul 31 09:56:15	1000	O	He–strong
391	16.2	2000 May 05 10:11:24	900	mid-B	
399	13.8	2000 Jul 10 08:19:54	120	∼B3	
411	16.8	2000 Jul 25 09:33:18	1080	DA	
423	16.5	2000 Jul 25 10:16:31	620	early-B	
437	15.5	2000 Jul 23 10:38:06	270	mid–late B	
441	14.5	2000 Jul 22 10:34:32	180	sdO+dM?	composite
443	10.8	2000 Jul 31 09:28:30	600	late B:	noisy
459	16.0	2000 Jul 29 07:15:11	1200	DA	
		2000 Jul 30 09:48:54	1500		
G209-30		2000 Jul 31 09:10:37	300	dM0–dM5	

Table 3
Observed Emission Line Strengths of Lanning 384

Ion and Transition	$F/F_{\mathrm{H}\beta}$	Ion and Transition	$F/F_{\mathrm{H}\beta}$
H I λ4341	0.53	[O I] λ6300	0.34
[O III] λ4363	0.10	[O I] λ6363	0.11
He II λ4686	0.57	[N II] λ6548	0.68
H I λ4861	1.00	H I λ6563	3.54
[O III] λ4959	1.67	[N II] λ6583	2.13
[O III] λ5007	5.15	He I λ6678	0.42
[N I] λ5198	0.09	[S II] λ6717	3.30
[He II] λ5412	0.04	[S II] λ6731	2.63
[He I] λ5876	0.19	He I λ7064	1.69